Interactive Computing

PRESS REVIEW

The Superchip

Vast Computing Power Is Seen as More Circuits Squeeze on a Tiny Part

Density Could Make Possible Machines That Can Read Print or Talk to People

Design, Cost Problems Loom

By Richard A. Shaffer
Staff Reporter of The Wall Street Journal

It's said that a machinist once engraved "How's this?" on the head of a pin and sent it to a fellow craftsman. The reply came back, "Not so hot," written on the head of the same pin—inside the "o" of "how."

Similar feats are becoming commonplace in the world of computers as more and more electronic circuits are squeezed into less and less space. The calculating power of yesterday's room-size computers is packed today into single chips, or pieces, of silicon almost small enough to pass through the eye of a needle. The chips—complex semiconductors called large-scale integrated circuits, or LSIs—contain thousands of transistors and other parts.

That will swell to hundreds of thousands or even millions of parts with the next step in miniaturization. It is known as very large-scale integration, or VLSI.

Many experts believe that VLSI will make it possible, perhaps within five years, to compress the number-handling prowess of a modern, large computer into a single part about the size of a match head. The advent of such superchips, they say, could prove to be as much a boon for the computer and semiconductor industries as the leap from transistors to integrated circuits in the early 1960s. For superchips may open the way to computers that anyone can use—compact, inexpensive machines able to talk to people and listen, to answer questions posed in everyday language, and to read print and handwriting.

Computers for Everybody

"If you think what we have today is amazing, just wait for VLSI," says George H. Heilmeier, vice president of corporate research, development and engineering at Texas Instruments Inc., the large maker of semiconductors. "Once people can interact with computers in their own terms," he says, the machines "will be everywhere, the way telephones and typewriters are today."

In giving birth to the promising superchip, however, industry faces a host of problems. VLSI will require costly and exotic new manufacturing methods because computer circuits already are so dense they are bumping against barriers posed by the laws of physics. In addition, manufacturers concede they don't yet know how to design circuits of far-greater density, nor whether the effort will be worth the cost, nor who will want all that number-crunching capability. "We're asking questions we never asked before VLSI," says Murray A. Goldman, operations manager of Motorola Inc.'s microcomputer group.

The shrinking chips—packaged in plastic with a dozen or more stubby connecting wires and resembling cubist centipedes—are the circuits that do the arithmetic and remember the information in computers. The rising number of transistors and other parts on each chip is the primary reason for the falling cost of computing, which has dropped about 40% a year since the introduction of integrated circuits in the early 1960s.

More Bits to a Chip

If progress continues at its present pace, one chip will be able to remember and recall about a quarter-million bits, or basic units of computer information, in another few years and a million bits a decade later, according to projections by several semiconductor manufacturers. The number of logic, or decision-making, computer circuits on a chip will climb to roughly 25,000 by mid-1980 and to a quarter-million five years later, the companies expect.

Ignoring development costs, such ultra-dense circuits could probably be manufactured for less than $100 apiece, according to Gordon Moore, president of Intel Corp., the Santa Clara, Calif., semiconductor producer.

For comparison, today's large computers—the size of several filing cabinets and selling in the $1 million range—contain about 100,000 logic circuits and a main-memory capacity of a few million bits.

More Reliable

Such cheap calculating power probably would make computers and machines that contain them much more reliable. "We'll be able with VLSI to afford to duplicate all the circuitry so that if part of it goes out, the computer will continue operating," says Gary S. Tjaden, director of advanced technology for Sperry Univac, the computer division of Sperry Rand Corp.

In addition, products already given some electronic intelligence by LSI chips—ovens, clocks, traffic lights, to name a few—will become smarter with VLSI. Thus, the electric office typewriter, which became the electronic typewriter with the addition of a few memory chips, could be transformed by a superchip into a complete word-processing system allowing a user to edit substantial quantities of text before putting the final version on paper.

Superchips may also give rise to the truly general purpose computer. "First, we'll see multiple central-processors in a single box," says Thomas Mandey, director of technology programs and computer studies at Quantum Sciences Corp., a New York technology-analysis company. "You'll be able to buy an IBM-type processor and, for a few hundred dollars more, get a Burroughs-type or Honeywell-type processor wired in as optional equipment. Next will come the chameleon machine, a computer that can imitate any other."

Perhaps most important is the VLSI cir-

The Superchip: Computing Power To Expand as Circuit Lines Shrink

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cuits' promise for building computers that adapt to people rather than requiring people to adapt to them. Encouraging steps in that direction are being taken with today's large computers. For example, International Business Machines Corp., Sperry Univac, and Bell Laboratories, the research arm of American Telephone & Telegraph Corp., have developed programs that enable computers to recognize continuous human speech.

At several so-called artificial-intelligence projects around the country, computers have been programmed to follow instructions and answer questions put to them in ordinary sentences, rather than in the jargon called programming languages that must be used in communicating with most computers. At some of these same laboratories, research in what is known as pattern recognition has provided machines with a crude sense of vision, enabling them to discriminate among various shapes and to read some free-form handwriting.

All of these programs have serious limitations at present. It would take the fastest machine half an hour or more, for example, to identify the words in a minute-long speech. Yet they work well enough to have commercial possibilities if only they weren't so expensive to operate. Superchips could go a long way toward moving such experimental programs out of the laboratory and onto the sales floor, according to Mr. Heilmeier of Texas Instruments.

"We must get ourselves out of the rut that says VLSI is simply going to make existing quantitative computation applications smaller, faster and cheaper—a straight-line projection of future trends based on the past," he says. "VLSI technology is the key to . . . machine intelligence that represents not a straight-line projection but a quantum leap in opportunities."

Limits of Light

While there are physical barriers to making circuits necessary for such futuristic computing, industry is finding ways to circumvent them. At some point, for example, makers of integrated circuits plan to abandon light and the photographic process on which they now rely.

The complex circuits are made like silk-screen prints, a layer at a time. Light is flashed onto a paper-thin piece of silicon through a glass negative, or mask, containing an image of part of the circuit. That pattern then is etched into the silicon, which is exposed to additional patterns and etched several more times until the circuit is complete.

But as the width of the circuit lines approaches the wavelength of the light used to create them, an effect known as diffraction causes several lines to appear where only one is intended. This effect, coupled with the tendency of lenses to absorb most light of wavelengths shorter than ultraviolet, limits photolithography to producing circuit lines wider than about 10,000 angstroms. (There are 240,000 angstroms in an inch.)

Small as that is—roughly the width of a yeast cell—it's too big for VLSI. So, in another few years, circuit-makers will be turning to beams of electrons to draw the patterns on the chips in something like the way pictures are generated on a television screen, a dot at a time.

Keeping Cool

Some of the companies eyeing electron beams also are looking at supercold circuits to avoid another barrier in microelectronics: heat. Computer circuits, which are switches, generate heat as they open and close. The faster they go, the hotter they get. Some of the quickest switches give off so much heat that to continue working, they must be kept far enough apart that the speed of the switch is offset by the relatively sluggish pace of the electricity reaching it, even though electricity zips along at about half the speed of light.

To deal with the restriction, experimenters at IBM are turning from semiconductors to superconductors, or metals so cold they have lost all resistance to electricity. One superconducting circuit, the Josephson junction—named for British Nobel Prize winner Brian Josephson—operates in a bath of liquid-helium at more than 400 degrees below zero. It opens and closes so quickly that the speed of a Josephson switch can only be measured by timing chains of a dozen and dividing by 12.

Overall, experts in solid-state electronics see no fundamental, physical limits to progress until circuits are a hundred or more times denser than they are today, containing lines only 100 angstroms wide, or about the diameter of a polio virus.

Yet superchips are raising concerns of a different sort among managers, marketing specialists and scientists at semiconductor and computer companies.

The movement, for example, from photolithography to electron-beam processing will sharply increase capital-equipment expenditures and probably further concentrate the industry around existing large companies, observers say. "Five years ago, it cost $5 million to set up a (semiconductor) wafer (manufacturing) line. Today it costs $15 million to $20 million, and the figure will be $30 million in another three years due to changing technology," says Pierre Lamond, technical director of National Semiconductor Corp., a Santa Clara, Calif., circuit maker.

Thus, Mr. Lamond believes, "VLSI will turn the cost of capital equipment into a major problem for the semiconductor industry. The investment required will be astronomical and to maintain a reasonable return on it very, very difficult—perhaps impossible for small firms."

In addition, some superchips will be so expensive and time-consuming to design that a mistake could be a financial disaster. The threat arises because of the difference between memory and logic circuits. The memory circuits store the information a computer is working on, together with instructions about what to do with it and when. Logic circuits do the arithmetic and make the decisions.

Complicated Logic

Designing a memory circuit is relatively easy. Once part of it has been drawn, a diagram containing almost any number of interconnected similar parts can be generated in minutes by computer.

But in a logic circuit, the elements are connected in a random fashion, vastly complicating the task. Added to that is the need to route all the connecting wires, without crossovers, in only two dimensions, because semiconductor chips are essentially flat. Finally, if a newly developed, one-chip logic circuit doesn't operate properly at first—as it almost certainly won't—repairs are far more than a matter of changing a wire or two, as with today's computers; the entire chip must be redesigned.

As a consequence, the cost of developing a logic superchip is likely to be so enormous that millions of such chips will have to be sold to justify it. Yet semiconductor and computing companies say they aren't really sure precisely what markets will be able to absorb such high levels of processing power.

"We've never been very good at answering questions like that," says James McGroddy, director of semiconductor science and technology at IBM. As a result, he says, "design costs are a serious limit to what we can do with VLSI. We and others are working to reduce those costs, and I believe we will invent a way. But it's important to focus on what's limiting us at any given time. We need to know where the wall is before we can knock it down."

A Computer Error: A Novice Tries To Operate One in His Own Home

Trying to Use One In Your Own Home

* * *

Our Man Finds He Can't Get It to Do Tax, Other Jobs; But a Physicist Is Happy

By MITCHELL C. LYNCH
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BOSTON—I got a spiffy $599 home computer for Christmas. And it stopped playing blackjack with me by New Year's Day, asked me "WHAT?" about 1,400 times by George Washington's Birthday, and mysteriously broke down and resurrected itself by Easter.

I thought it would straighten out the family budget; it didn't. The ads said it would help educate the kids; it hasn't. Certainly it would do my tax returns; it can't. At least it would teach me how to prepare those fancy programs for computers; it didn't. Indeed, if I hadn't been assigned to work with my computer, it would be gathering dust in my attic.

Trying out one of the exercises in the instruction book, I spent more than an hour just typing into the computer a copy of the program instruction—never mind devising my own program—for Robert Frost's poem, "Stopping by Woods on a Snowy Evening." It was gorgeous. There, right on my desktop video screen softly flowed "Whose woods these are I think I know . . " with electronically created *snowflakes* lazily falling in the background. Then I pressed a wrong button, and the poem and the snowflakes vanished — permanently. Blip.

Lack of Training Hurts

Most of which is my fault. I've since learned. Experts say people like me have neither the technical training nor technical inclination to make a home computer—in my case a Tandy Corp. Radio Shack TRS-80—strut its stuff. "Your problem," one computer-company executive says, "is that you probably don't even like to program." True.

In a way, though, my ignorance is more his problem than mine. Many computer makers are proclaiming that the long-awaited age of the home computer is upon us, but my experience suggests something else: Most Americans probably aren't ready for it. As one study puts it, most people with enough money to make the purchase "do not have the time or patience to fool with a computer." Today's home computers require a lot of fooling with.

"The average home consumer today doesn't know much about the technology of a computer, and he really doesn't want to know," says Phil Roybal, marketing manager of Apple Computer Inc., a fast-growing, privately owned Cupertino, Calif., company that also sells personal computers. Among other companies expected to be competing soon against Tandy, which markets electronic equipment through 7,000 Radio Shack stores, are Texas Instruments Inc. and Hewlett-Packard Co.

Creative Strategies International, a market-research firm in San Jose, Calif., estimates the current market for household computers at 18 million. The other 57 million households won't be able to afford a computer until 1982 or so, when presumably prices will fall enough, Creative Strategies says. Vantage Research Inc., which specializes in analyzing the computer market, estimates that by 1982 personal-computer sales will reach $1.1 billion, of which $640 million will come from average consumers, $330 million from so-called professionals—people who use their computers for their jobs—and $185 million from "hobbyists"—people who simply like to play with computers.

Selling Well

Right now, no one knows precisely how many home computers have been sold. Andrew Roman, a consultant at Creative Strategies, estimates that by year-end 600,000 will have been installed in homes and that another 500,000 home-type computers will be in offices, laboratories and classrooms. More than 40 companies are making these computers, he says, and "they're selling them as fast as they can make them."

These figures are all the more remarkable because such gadgets didn't even exist until 1975, when the development of low-cost microprocessors made home computers practical. Microprocessors are silicon chips, usually no more than a quarter-inch square but carrying as much calculating power as big circuit boards.

The huge potential markets may have tempted a few companies to jump the gun in trying to sell home computers, some observers say. "The companies—and even the press—have given this futuristic image of what computers can do in the home, when in fact they can't do much," a computer-industry expert says. Stories abound about how the low-priced machines can store information and cough it up on demand for, say, preparing tax returns, switching lawn sprinklers on and off, regulating air temperature and quality in homes to save energy, controlling family budgets, helping teach children and speeding access to family records such as recipes and Christmas-card lists.

Mine can't—at least not yet and not for $599. Yet my Tandy microcomputer was heavily advertised before Christmas as a handy gift that was inexpensive for what it can do. (To set the record straight, Tandy rented the computer to me for a small fee paid by this newspaper. My editors chose me because I'm supposed to be "typical": married, two children, a dog, a cat and a mortgage.)

To the uninitiated like me, the Tandy would seem to be a dandy—the fastest-selling, most-heavily-advertised personal computer on the market. It has a video screen, a keyboard, a small black box known as the power supply, a cassette tape recorder and the 232-page book of instructions written, it says, "specifically for people who don't know anything about computers." (Another reason I was picked for this assignment.) Among the things the computer can do is play games with you.

Like blackjack. Insert a cassette into the tape recorder, "load" it into the computer and, presto, a blackjack game appears on the screen. The family loved it—for one day. Then, inexplicably, the machine quit playing. At the local Radio Shack store, the clerk, brow furrowed, asked, "Did you put the tape near the power-supply box?" Drawings in the instruction manual show the tape recorder right next to that box, I replied weakly. "If you *read* the manual," he admonished, "you'll see that the power-supply box generates a magnetic field, and the magnetic field will erase the tape." Oh.

So my wife and I came up with a better game: inviting friends over to admire the computer and then asking them what they would do with it. "Recipes," one woman ventured. "What do I do, take the screen into the kitchen?" my wife cracked for the umpteenth time. Another guest suggested, "How about your checking account, your budget, those kinds of things?" Tried it, I said, and it didn't work. (Actually, I bought Radio Shack's $20.90 "personal finance" kit, but, so help me, the tapes mysteriously erased the very first time.)

Hence, the somewhat-depressing conclusion: My home simply isn't complex enough to need a computer. I'm not alone. Americans have yet to feel what Benjamin M. Ro-

sen, an electronics-securities analyst at Morgan Stanley & Co., calls a "perceived need" for a home computer. The computer, with all its potential problem-solving abilities, is akin to "a solution looking for problems," Mr. Rosen says.

Programming Problems

Consider programming. The TRS-80 uses what is called the BASIC language, meaning "beginners all-purpose symbolic instruction code." Such computer-language is also all-fired precise. If you type in a line of instructions and you misplace just one character, the computer screen will print "WHAT?"

Here are the first four of 54 lines in the program for Robert Frost's poem:

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40 CLS
50 P.AT7, "ON  A  SNOWY  EVE-
NING . . . . . BY ROBERT FROST";
55 F.N=1TO2000:N.N
68 F.Z=1TO3000
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Why are the lines numbered 40, 50, 55, and then 68? What does "CLS" mean? Why the period after "P"? Why are the quote marks needed? It's all in the manual. If any of the periods, commas, semicolons or the rest are left out, the computer will ask "WHAT?" An untrained programmer gets snowed under with "WHAT?"

So, some companies are rushing in with all kinds of "software"—tapes or record-like disks containing programs. Someday soon, computer experts say, I'll be able to buy software to make my TRS-80 hum—but not yet.

Some Happy Buyers

Some people already can make their TRS-80s hum, of course. A. Richard Miller, a Natick, Mass., physicist, likes his TRS-80 so much that he formed Miller Microcomputer Services, a company that sells programs and advises clients, mostly small businessmen and professionals, how to tailor their computers to their needs. Mr. Miller also heads one of about 50 TRS-80 clubs that have sprung up across the country and whose members, generally hobbyists, hold what they call "microsessions" to watch demonstrations and trade new ideas.

However, even Mr. Miller doesn't see much practical use for the computer in the home, and he estimates the minimum cost of a microcomputer ensemble, including programs and other software, at $3,000. "There is a tremendous gap between what the computer can do and what most people can make it do," Mr. Miller says. In fact, a minor part of his business is to buy used TRS-80s from the disenchanted.

Meanwhile, back at my house, my computer simply sputtered out one day. The screen wavered and flickered, but wouldn't take a word I printed or answer me. I took the whole ensemble back to the store, and there the computer worked fine. "I can't imagine what happened," the manager said.

Another Aspect

All of this — the mysteriously erased tapes, the disappearing poem, the collapse at home and the resurrection at the store—are part of what computer people call the "debugging" process of a fledging industry. But there is more to it than that.

John Roach, executive vice president of Tandy's Radio Shack unit, bluntly says the TRS-80 "isn't being used in the home the way most people want to use it; we recognize we weren't able to provide the software." The real market, he adds, comprises business and professional buyers willing to lay out much more money for computer upgrading, attachments such as printers, and all kinds of software.

But what about Radio Shack's pre-Christmas ads, in newspapers and on television, showing the happy family under the Christmas tree? "Those were aimed at the education market," Mr. Roach says, "for the children to use for their studies."

The Guilt Pitch

Says Morgan Stanley's Mr. Rosen: "It's called the encyclopedia-guilt sales pitch. Parents are supposed to feel they should buy one for the kids."

And indeed, one of the hot markets that computer makers are vying for is the school systems, where industry executives envision microcomputers atop the desks. And although the schools in my town don't offer computer-education courses, at least not for my children's age groups, many high schools across the country do provide such instruction. Moreover, industry executives are hoping that eventually these young people—with some computer training and without the hang-ups that make their parents wince at the idea of running a computer—will take easily to the notion of buying and operating one.

And Mr. Rosen warns critics not to "pooh-pooh the personal computer." The business and professional market is so big that nobody knows how many computers it will absorb, he says. Meanwhile, technological advances are being made so rapidly that Americans indeed will find a need for computers at home, he says, adding, "Sometime in the 1980s they will be a consumer product."